Aerospace Technology
FY 2003 PERFORMANCE PLAN

1. Mission: The Office of Aerospace Technology (OAT) Enterprise mission is to maintain U.S. preeminence in aerospace research and technology. The Enterprise plays a key role in 1) maintaining a safe and efficient national aviation system 2) enabling an affordable, reliable space transportation system, and developing basic technologies for a broad range of space missions. Research and development programs conducted by the Enterprise also contribute to NASA's science and exploration missions, national security, economic growth, and the long-term competitiveness of American aerospace companies.

A modern air and space transportation system is fundamental to our national economy, quality of life, and security of the United States, For 75 years, a strong base for aerospace technology research and development has provided enormous contributions to this system, contributions that have fostered the economic growth of our Nation and provided unprecedented mobility for U. S. citizens. Although major technical advances have made our Nation's air and space transportation system the largest and best of its kind, the future holds critical challenges to its continued growth and performance. Because the U. S. air and space transportation system serves both critical national security needs and the public good, ensuring the continued health and preeminence of that system is a key issue for the future of the Nation.

In order to develop the aerospace systems of the future, revolutionary approaches to system design and technology development will be necessary. Pursuing technology fields that are in their infancy today, developing the knowledge bases necessary to design radically new aerospace systems, and performing efficient, high-confidence design and development of revolutionary vehicles are challenges that face us in innovation. These challenges are intensified by the demand for safety in our highly complex aerospace systems.

Although NASA technology benefits the aerospace industry directly, the creative application of NASA's advanced technology to disparate design and development challenges has made numerous contributions to other areas such as the environment, surface transportation, and medicine.

2. Resource Requirements:

	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003
NOA $M	1,339	1,125	1,404	2,508	2,816
CS FTE	4,227	4,345	6,170	6,140	6,344

3. Implementation Strategy: The foundation for the Aerospace Technology Enterprise program is based on the accomplishment of three goals. (A fourth goal, Commercialize Technology, is addressed in NASA's crosscutting goals: Providing Aerospace Products and Capabilities (APG 3P7) and Communicate Knowledge (APG 3CK3) performance plan.) Enterprise objectives are outcome-focused and "stretch" beyond our current knowledge base. The outcome-focused nature of the objectives projects a preferred end-state within the air and space transportation and mission spacecraft and instrument systems. The Enterprise goals are:

Goal 1 – Revolutionize Aviation: Enable the safe, environmentally friendly expansion of aviation. Expanding the aviation system of the future to meet demands for growth will mean providing a more distributed, flexible, and adaptable network of airways. This growth must take place within the physical and environmental constraints of today's system, while meeting the evolving needs of air travel. The system of the future will continue to be international in scope, requiring close coordination across a global network. Advanced vehicles will operate in this new infrastructure with better performance and new capabilities. Advanced information and sensor technologies will make air travel safer and more efficient. Air transportation will be easily accessible from urban, suburban, or rural communities. Airplanes will be cleaner, quieter, and faster. NASA aims to revolutionize aviation by delivering the long-term, high payoff aerospace technologies, materials, and operations, research needed for enabling these new vehicle and system characteristics and capabilities.

Goal 2: – Advance Space Transportation Create a safe, affordable highway through the air and into space. Revolutionizing our space transportation system to significantly reduce costs and increase reliability and safety will open the space frontier to new levels of exploration and commercial endeavor. With the creation of the Integrated Space Transportation Plan (ISTP), NASA defined a single, integrated investment strategy for all its diverse space transportation efforts. By investing in a sustained progression of research and technology development initiatives, NASA will enable future generations of reusable launch vehicles and in-space transportation systems that will surmount the Earth-to-orbit challenge and allow less costly, more frequent, and more reliable access to our neighboring planets and the stars beyond.

Goal 3 – Pioneer Revolutionary Technology: Enable a revolution in aerospace systems. In order to develop the aerospace systems of the future, revolutionary approaches to system design and technology development will be necessary. Pursuing technology fields that are in their infancy today, developing the knowledge bases necessary to design radically new aerospace systems, and developing tools for efficient high-confidence design and development of revolutionary vehicles are some of the challenges that are being addressed. In addition, the NASA Aerospace Enterprise is also developing the fundamental new technologies that will be used by other NASA Enterprises to accomplish their strategic Objectives. In these cases, the technology transition plans are developed that will allow the smooth incorporation of these revolutionary technologies into NASA missions. These technologies will enable the collection, analysis, and distribution of increased and previously unobtainable scientific data and discoveries in an expeditious and efficient manner.

The Aerospace Technology Enterprise program work breakdown structure has been restructured to create a clear linkage between the Enterprise strategic goals and the program management structure. This restructuring creates an unambiguous linkage from National policy, to the Agency strategic plan to the budget and provides a foundation for transparent, measurable performance reporting. Enterprise programs are often conducted in cooperation with other Federal agencies, primarily the Federal Aviation Administration and the Department of Defense. These partnerships take advantage of the national investment in aeronautics and space capabilities and eliminate unnecessary duplication. The Enterprise supports the maturation of technology to a level such that it can be confidently integrated into current and new systems. In most cases, technologies developed by the Enterprise can be directly transferred to the external customer. The Enterprise approach for implementing the program begins with investment decisions based on rigorous systems analysis. Independent programmatic and expert reviews will provide supplemental information that will be incorporated in management decisions. Annual program reviews will be used to measure progress (technical, schedule and cost) against requirements and deliverables, and outside expert technical reviews will assure the quality of the products and future directions to meet strategic goals. The Enterprise research and technology programs are:

Revolutionize Aviation – Aviation Safety Program: The Aviation Safety program is developing and demonstrating technologies and strategies to improve aviation safety by reducing both aircraft accident and fatality rates. The program is structured around developing technologies along three major thrusts: (1) aviation system monitoring and modeling to help aircraft and aviation system operators identify unsafe conditions before they lead to accidents; (2) accident prevention in targeted accident categories, including system-wide, single aircraft, and weather; and (3) accident mitigation to increase accident survivability in those cases when accidents do occur.

Revolutionize Aviation – Vehicle Systems Program: The Vehicle Systems program is taking advantage of the emergence of revolutionary advances in biotechnology, nanotechnology, and information technology to enable significant advances it the functionality of 21st Century aircraft. It consists of a balance of mid- and far-term technology development activities, including the areas of materials, structures, aerodynamics, flight control, propulsion, and power, and the integration of these technologies into new vehicle concepts. Experimental vehicles will be developed for flight-testing to further mature the technologies that can be developed with government and industry partners into high leverage products.

Revolutionize Aviation – Airspace Systems Program: The objective of the Aviation System Capacity Program is to enable improvements in mobility, capacity, efficiency and access of the airspace system by developing, validating and transferring technologies that improve collaboration, predictability and flexibility for the airspace users, enable runway-independent aircraft, provide more access for general aviation operations, and maintain system safety and environmental protection. The program is developing decision support tools that will be transferred to the Federal Aviation Administration and the airlines, as well as an airspace systems modeling capability to simulate and analyze new and innovative future air traffic management concepts. Additionally, the program is developing airborne technologies for precision guidance of small aircraft to virtually any small airport to create alternative means to respond to the demand for increased throughput in the National Airspace System in the near term.

Advance Space Transportation – 2nd Generation Reusable Launch Vehicle Program: The 2nd Generation Reusable Launch Vehicle (RLV) program performs systems engineering, technology development and architecture definition trade studies to define at least two 2nd Generation RLV architecture designs that will best meet the requirements to make access to space safer, more reliable, and less expensive for present and future customers. The systematic approach targets the research and development of high-priority advanced technologies to be integrated into at least two vehicle architectures to provide the foundation for future potential full-scale development decisions.

Advance Space Transportation – Space Transfer and Launch Technology Program: The Space Transfer and Launch Technology program is developing high-payoff technologies for the 3rd generation of reusable launch vehicles to enable missions that are currently not technically or economically feasible. The efforts are centered around integrated ground demonstrations of potential hypersonic launch platforms, including rocket based combined cycle systems, turbine based combined cycle systems and flight demonstration of high speed scramjet propulsion/airframe integration, for safe, routine earth-to-orbit transportation to enable new commercial space markets, ensure seamless aerospace national security and enable the human exploration and development of space.

Pioneer Revolutionary Technology – Computing, Information and Communications Technology Program. The Computing, Information and Communications Technology program is developing and demonstrating revolutionary computing, information and communications technologies in the specific areas of autonomy, human-centered systems, intelligent data understanding, advanced computing and networking, information environments, and fundamental information, bio- and nano-technologies. Through their integration and transfer into aerospace systems and missions, these new technologies will enable: smarter, more adaptive systems and tools that work collaboratively with humans; seamless access to ground-, air- and space-based distributed hardware, software and information resources to enable NASA missions in aerospace, Earth science and space science; and broad, continuous presence and coverage for high rate data delivery from ground-, air-, and space-based assets directly to the users.

Pioneer Revolutionary Technology – Enabling Concepts and Technologies Program. The Enabling Concepts and Technologies program provides revolutionary aerospace system concepts that can enable NASA's strategic visions and expand future mission possibilities. As the front end of the enabling technology pipeline that feeds the focused technology development programs of NASA's Enterprises, the program develops potentially high pay-off technologies that may involve considerable risk to successful or rapid development. These areas include: sensing and spacecraft systems to enable bold new missions of exploration and to provide increased scientific return at lower cost; advanced energetics technology to provide power, propulsion, and electric thrust augmentation for enhanced mission capabilities and to enable missions beyond current horizons; and fundamental research in high-payoff spacecraft technologies such as micro-electronic and mechanical systems (MEMS), high performance materials, and nanotechnology to stimulate breakthroughs that could enable new system concepts.

Pioneer Revolutionary Technology – Engineering for Complex Systems Program. The Engineering for Complex Systems program has a three-pronged approach to achieving its objective of enabling ultra-high levels of safety and mission success through the infusion of advanced information. First, the program intends to significantly advance the scientific and engineering understanding of system complexities and failures, including human and organizational risk characteristics. Second, processes, tools and organizational methods will be developed to quantify, track, visualize and trade-off system designs and/or mission options with an emphasis on risk management throughout the system lifecycle. Third, software based resiliency tools and technologies will be developed to help mitigate risk in the operational and maintenance phases of the program lifecycles.

4. Performance Metrics:

Goal 1 – Revolutionize Aviation: Enable the safe, environmentally friendly expansion of aviation.

Objective One – Increase Safety: Make a safe air transportation system even safer by reducing the aircraft accident rate by a factor of 5 by 2007 and by a factor of 10 by 2022.

Strategy:

- **System Monitoring and Modeling:** Develop technologies for using the vast amounts of data available within the aviation system to identify, understand, and correct aviation system problems before they lead to accidents.

- **Accident Prevention:** Identify interventions and develop technologies to eliminate the types of accidents that can be categorized as "recurring."
- **Accident Mitigation:** Develop technologies to reduce the risk of injury in the unlikely event of an accident.

Public Benefit: These innovative technologies will improve the safety of the flying public. The public benefit can be characterized in three ways: (1) elimination of major categories of recurring accidents; (2) early warning and prevention of hidden and potential safety issues, and (3) reduced risk of injury to passengers and crew in the unlikely event of an accident.

Technical Approach: The Aviation Safety program has examined the historical aviation accident trends and determined high payoff technologies that will improve the safety of the National Airspace System. In cooperation with the Federal Aviation Administration and the aviation industry, research and technology will address accidents and incidents involving hazardous weather, controlled flight into terrain, human-performance related casual factors, and mechanical or software malfunctions and the development and integration of information technologies needed to build a safer airspace system and provide information for the assessment of situations and trends that indicate unsafe conditions before they lead to accidents. The program is structured into three investment thrust areas consisting of vehicle safety, weather safety and system safety technologies. These investment areas address targeted accident categories, as well as known accident precursors, aviation hazards and human survival rates when accidents do occur and cover all parts of the aviation system, including aircraft, people, and operations. In addition, the Vehicle Systems program will explore revolutionary and high-risk technology that will significantly improve the safety of future generations of aircraft and engine systems.

APG 3R1: Demonstrate progress in maturing, through flight tests and/or simulations, the critical technologies that will be necessary to meet the aviation safety objective. These tests and simulations are critical steps in the development of a suite of technologies that when completely developed and implemented by the customer, will provide a minimum of 50 percent reduction in fatal accident rate.

Performance Indicators:

System Monitoring and Modeling

- Demonstrate fast time simulation of system wide risks
- Model high error rate probability context and solution

Accident Prevention

- Provide new software certification procedures
- Demonstrate flight critical system validation methods
- Demonstrate a smart icing system that will sense the presence of ice accretion on the aircraft, automatically activate and manage the ice protection systems, and provide the pilot with feedback including the effect on measured aircraft performance, stability and control
- Complete initial flight evaluation of synthetic vision concepts
- Complete initial evaluation of a next-generation cockpit weather information and digital datalink technologies

- Validate life prediction methodology for critical powder metallurgy super-alloy engine components (nickel-based turbine disk) to enhance aircraft safety
- Initiate intelligent flight control generation I flight test
- Conduct flight testing of the research flight computing system which includes intelligent flight control and propulsion control
- Develop a transient disturbances recovery strategy for implementation in the SPIDER architecture

Objective Two – Reduce Emissions: Protect local air quality and our global climate by reducing oxides of nitrogen (NO_X) emissions of future aircraft by 70 percent by 2007 and by 80 percent by 2022 (Baseline: 1996 ICAO Standard) and also reducing carbon dioxide (CO_2) emissions of future aircraft by 25 percent by 2007 and by 50 percent by 2022.

Strategy:

- **Airframe Weight and Drag Reduction:** Develop airframe technologies that reduce fuel consumption and therefore reduce CO_2 and NO_X emissions.
- **Propulsion Optimization:** Develop advanced engine system technologies to reduce emissions such as NO_X that have an impact on local air quality and those such as CO_2 that affect the global climate.
- **Operation Optimization:** Develop more efficient operations at and around airports, in order to reduce aviation fuel burn and therefore reduce emissions.
- **Alternative Vehicle Concepts:** Develop advanced concepts for propulsion systems, airframe structures, and fuels that dramatically reduce or completely eliminate emissions from civil aviation aircraft.

Public Benefit: NO_X emissions are a known pollutant that degrades local air quality CO_2 emissions affect global air quality and have been identified as a major driver of climate change.. In summary, the public benefit of the NASA technologies can be characterized in three ways: (1) significant or total elimination of aircraft emissions as a source of climate change, (2) minimization of the impact of aviation operations on local air quality, and (3) elimination of unnecessary aviation emissions due to operational procedures. Another potential benefit of significantly improved vehicle efficiency is reduced air travel costs.

Technical Approach: NASA is addressing this problem by developing critical engine technologies that provide a significant reduction in emissions (primarily NO_X) as well as both airframe and other engine technologies that provide a dramatic increase in efficiency that will result reduced fuel burn. Reduced fuel burn leads to a reduction in total emissions, including carbon dioxide (CO_2). Independent assessments will be made throughout the life of the programs to evaluate our progress towards these ambitious goals and provide a sound foundation to make adjustments in technology investments. Adequate technology maturation from subcomponent testing in the laboratory, to component testing in more realistic environments, to full integrated testing in a relevant environment will be key to ensuring that these technologies are used in future air fleets. The technology development efforts are being conducted in close cooperation and coordination with the Department of Defense and industry.

The NO_X emissions reduction objective (70 percent landing and takeoff (LTO) NO_X reduction) will be accomplished via advanced combustor designs. NASA will continue to build on the knowledge gained through the development of the low NO_X combustor technology, which demonstrated a 50 percent NO_X reduction and is now being incorporated in production engines, to achieve the 70 percent goal. Several promising technologies have met the 70 percent goal in laboratory tests (i.e. flame tubes) and are being prepared for sector tests. This is one of a series of tests (i.e. sector, annular and full combustor) with intervening modifications and enhancements that are be required to maintain performance during these increasingly more demanding tests. This process ensures that the technology is developed sufficiently for subsequent transfer to industry.

CO_2 reduction is directly related to fuel burn and as the fuel burn decrease; both the CO_2 and NO_X emittants decrease. To achieve the reductions in fuel burn, NASA is developing technologies that will produce more efficient engines and airframes. Specific engine technologies that are being pursued include revolutionary, highly loaded compressor and turbine designs, ultra effective cooling configurations in turbines and combustor, innovative engine and airframe integration methods, and high temperature, durable propulsion materials supporting more efficient and higher performance cycle operations. The airframe effort is focused on the use of advanced materials and technologies to reduce weight and drag of current aircraft and engine configurations. In addition non-traditional aircraft configuration and propulsion systems (e.g., fuel cells) will be investigated for feasibility including an assessment of the potential benefits and technology barriers.

APG 3R2: Complete combustor sector test for concepts capable of achieving the 70%NO_X goal by 2007 and select the most promising approaches leading to full annular rig testing for large and regional jet engine applications. Complete an Interim Technology Assessment of the aggregate potential benefits from the engine and airframe technologies to reduce emissions. The results from this analysis will provide a benchmark for measuring overall progress, and guide future investment decisions.

Performance Indicators:

Airframe Weight and Drag

- Demonstrate the fabrication of carbon nanotube laminates
- Demonstrate advanced aeroelastic wing twist (flexible wing) on an F-18 to determine available roll power.
- Complete laminar flow experiment on F-15 testbed
- Demonstrate adaptive drag reduction techniques

Propulsion Optimization

- Engine test a coated polymer matrix composite inlet guide vane
- Simulate a benchmark combustion experiment with a liquid spray injector
- Develop a ceramic matrix composite (CMC) turbine vane
- Demonstrate a CMC complex part in rig test
- Downselect large engine contractor for full annular combustor testing
- Downselect regional engine contractor for full annular combustor testing
- Complete sector evaluations of 70% LTO NO_X configurations
- Complete an interim technology benefits assessment

Alternative Vehicle Concepts

- Complete evaluation of active flow control concepts for propulsion airframe integration (PAI)
- Complete initial high Reynolds number validation in wind tunnel of PAI method
- Complete evaluation of estimated technology benefits on future vehicle concepts
- Complete flutter risk assessment of high-speed slotted wing
- Validate nonlinear structural analysis tools
- Conduct testing of Stingray vehicle (morphing)
- Complete oil free FJX-2 core testing
- Demonstrate a prototype electric powered UAV capable of sustaining 14 hours of operation above an altitude of 50,000 feet

Objective Three – Reduce Noise: Benefit airport neighbors, the aviation industry, and travelers by reducing the perceived noise of future aircraft by a factor of two (10 decibels) by 2007 and by a factor of four (20 decibels) by 2022 (using 1997 subsonic aircraft technology as the baseline) thereby confining aircraft noise to within the airport boundary.

Strategy:

- **Propulsion System Source Noise Reduction:** Develop technologies to reduce engine noise at the source.
- **Aircraft System Source Noise Reduction:** Develop technologies to diminish airframe-related noise.
- **Operational Noise Reduction:** Develop advanced aircraft operating procedures, including steeper glide-slopes and precision, wind-compensated flight paths

Public Benefit: Reduction in noise impact surrounding airports, ultimately confining objectionable air transport noise within the compatible land-use areas around airports will benefit homes and businesses located close to an airport and enable faster and more efficient growth in the nation's air system by reducing constraints on where new airports and runways can be located.

Technical Approach: NASA is conducting a balanced effort at making major advances in noise reduction by 2007 and looking to high impact technologies to affect the more substantial targets of 2022. The work to be completed in FY 2003 provides the foundation for the future developmental efforts and has demonstrated technologies that when incorporated in aviation systems will result in an additional 2-decibel reduction from the 1997 baseline aircraft. The fundamental understanding of source noise mechanisms gained from computational, as well as experimental diagnostic investigations, will lead to the discovery and optimization of component noise reduction concepts necessary to achieve the Enterprise 10 decibel noise reduction objective. A critical step in the achievement of the Enterprise goals will be the development and validation of advanced physics-based noise prediction models. These models will be used to identify and assess the benefits of potential engine and airframe noise reduction technologies as well as improvements tat could result from changes in aircraft operations. Technologies and operational concepts will be selected for development and subsequent validation in laboratory and flight experiments.

Adequate technology maturation from subcomponent testing in the laboratory, to component testing in more realistic environments, to full integrated testing in a relevant environment will be key to ensuring that these technologies are used in future air fleets.

Independent assessments will be made throughout the life of the programs to evaluate progress towards these ambitious goals and make adjustments in technology investments.

APG 3R3: Complete development of initial physics-based prediction models to guide the development potential noise reduction technology concepts. Complete an interim technology assessment of the potential benefits for these concepts to reduce noise emissions. The results from this analysis will provide a benchmark for measuring overall progress, and guide future investment decisions.

Performance Indicators:

Propulsion System Source Noise Reduction.

- Three-dimensional noise propagation code for engine nacelles

Aircraft System Source Noise Reduction

- Develop initial physics-based noise prediction models

Operational Noise Reduction

- Quantify potential benefits of advanced noise abatement profiles and procedures at key airports

Integrated Activities

- Complete an interim technology benefits assessment
- Develop initial physics-based noise prediction models

Objective Four – Increase Capacity: Enable the movement of more air passengers with fewer delays by doubling the capacity of the aviation system within 10 years and tripling it within 25 years based on 1997 levels.

Strategy:

- **Infrastructure and Operation Optimization:** Optimize use of the current infrastructure without adding new airports or new runways by developing air traffic management technologies that increase the efficiency and capacity of the National Airspace System (NAS).
- **Alternative Vehicle Concepts:** Develop new civil aviation vehicle concepts that are designed to use segments of the NAS not suited for traditional commercial aircraft, such as short runways and vertical take-off and landing pads.
- **Alternative Infrastructure Concepts:** Develop entirely new concepts and systems, such as fully automated towers and airports that would increase the use and capacity of the Nation's 5000 public-use airports.

Public Benefit: Increase the capacity of the NAS sufficiently to meet projected public demand and alleviate delays without compromising safety. Although the events of September 11 have temporarily reduced demand on the nation's air system, delays are expected to return as demand for passenger and cargo flights increase.

Technical Approach: As part of the Airspace Systems Program, and in cooperation with the FAA, development of airspace systems technologies capable of meeting the strategic goal is being approached through two paths. First, to improve the gate-to-gate air traffic management and control process to increase capacity within the existing and planned aviation system for the next 15 years, the AATT project focuses on developing decision support technologies to assist air traffic controllers, pilots and aircraft operators in using airspace more efficiently through reduced spacing, improved scheduling, collaboration with operators, and other techniques. The project is conceiving new tools, developing them through laboratory simulations, and maturing them through field-testing. Some tools have been delivered to and accepted by the FAA for implementation in their "Free Flight" concept, some tools are in field testing and others are in the laboratory development phase. Second, in the first steps toward evaluating concepts of air traffic management that will enable three times the capacity, the Virtual Airspace Modeling and Simulation (VAMS) project, initiated in FY 2002, will establish a virtual airspace simulation environment for the test and evaluation of new and innovative solutions to the nation's aviation system problems. The challenge that technology development will address is the need for real-time analysis with never-before-achieved fidelity of a complex system. This capability is key to evaluating revolutionary air traffic management operational and technological concepts to dramatically reduce airport congestion and delays while maintaining or increasing air system safety and provide the information needed to establish a direction for the future air traffic management system beyond the technologies developed under AATT

APG 3R4: Complete development, initial functionality and evaluate human factors for at least one decision support tool to enable achievement of the planned progress towards the goal of doubling the capacity of the National Airspace System in 10 years. Complete the initial build of a toolbox of state-of-the-art airspace models to enable the planned progress towards the 2022 Objective.

Performance Indicators:

- Develop, demonstrate initial functionality, and evaluate human factors for a decision support tool for complex airspace
- Develop, demonstrate initial functionality, and evaluate human factors for an active terminal area decision support tool
- Complete initial build of state-of-the-art airspace model toolbox
- Provide strategies for improving training and procedures to reduce misunderstandings between pilots and air traffic controllers

Objective Five – Increase Mobility: Enable people to travel faster and farther, anywhere, anytime by reducing the time for inter-city door-to-door transportation by half by 2007 and by two-thirds by 2022, and reducing long-haul transcontinental travel time by half by 2022

Strategy:

- **Small Aircraft Transportation:** Develop vehicle, communication, and information technologies to allow small aircraft to operate easily and affordably at small airports in most weather conditions.
- **Supersonic Transportation:** Develop technologies critical to the economic viability of supersonic transport, such as propulsion concepts that meet stringent noise and emissions criteria.
- **Advanced Mobility Concepts and Technology:** Investigate non-traditional vehicles and operations concepts to take advantage of operational airspace that is currently underused.

Public Benefit: By developing new technologies that could permit small aircraft operations during near all weather at thousands of airports in the United States the capability of the nation's air system to transport goods, individuals, families, or groups of business associates could be greatly increased. The Small Aircraft Transportation System (SATS) concept is conceived as a safe travel alternative freeing people and products from constraints of today's ground and air transportation systems, by creating access to more communities in less time. The SATS concept increases reliable air access to virtually any community could lead to transportation services that improve all aspects of quality of life. While not specifically designed for current commercial operations, over time, the targeted technologies would also provide benefits to commuter and major air carrier operations in the hub-and-spoke system as well, through other focused research programs.

Technical Approach: The technical approach for the program operates through a joint public-private R&D collaboration involving NASA, the DOT, FAA, and state & local authorities, universities, industry, and transportation service providers. The program balances technology development, technology validation and demonstration, and technology assessment and includes laboratory, simulation, and flight experiments. These technical efforts integrate selected airborne enabling technologies to create and demonstrate four specific SATS operating capabilities. Products will include the design guidelines, systems standards, and identification of certification issues for the enabling technologies and operating capabilities.

APG 3R5: Select candidate technologies for experimental flight evaluation based on their impact on mobility. Mobility metrics will be measured by accessibility, doorstep-to-destination transit time, system and user costs, and related trip reliability and safety metrics. These flight experiments will evaluate individually, at the sub-system level, the impact of selected technologies on lowering required landing minimums and increasing the volume of operations at non-towered landing facilities in non-radar airspace during instrument meteorological conditions.

Performance Indicators:

Small Aircraft Transportation

- Select flight experiment technologies
- Complete lower landing minimum flight experiment
- Complete higher volume operations flight experiment
- Evaluate integrated single-crew flight deck technologies
- Demonstrate increased mobility without compromising enroute capacity

Advanced Mobility Concepts and Technology

- Demonstrate the fabrication of carbon nanotube laminates
- Validate nonlinear structural analysis tools
- Publish AWS validated figures of merit and design guidelines
- Conduct Stingray vehicle testing (Morphing))

Goal 2 – Advance Space Transportation: Create a safe, affordable highway through the air and into space.

Objective Six – Mission Safety: Radically improve the safety and reliability of space launch systems by reducing the incidence of crew loss for a second generation Reusable Launch Vehicle (RLV) to 1 in 10,000 missions (a factor of 40) by 2010 and to less than 1 in 1,000,000 missions (an additional factor of 100) for a third generation RLV by 2025.

Strategy:

- **Reusable and Robust Propulsion Systems:** Develop technologies for inherent reliability, more robust subsystems, and an increased performance margin for propulsion and power systems.
- **Integrated Vehicle Health Management:** Develop advanced sensors and algorithms to integrate intelligence, such as real-time failure detection and isolation, into vehicle systems.
- **Crew Escape:** Develop systems to remove the crew safely from a vehicle in the event of catastrophic failure during the highest risk phases of a mission, including vehicle ascent and descent

Public Benefit: A safe earth-to-orbit space transportation system is a key enabler of the commercial development, civil exploration and National security of space. Human space flight remains a hazardous endeavor in spite of advances in aerospace technology.. NASA intends to substantially increase the safety of routine space operations by developing the technologies and architectures for the next generation of RLVs and by concurrently developing the advanced technologies that will be required for future generations of RLVs. These future vehicles and associated systems could enable a broad expansion in scientific research, open new commercial markets, improve national security, and the enable the human exploration and development of space.

Technical Approach (Next Generation): Building on 20 years of success with America's 1st Generation RLV—the Space Shuttle—the 2nd Generation RLV program defines the plan of action to design and develop America's next-generation RLV. In partnership with the Department of Defense (DoD), the U.S. aerospace industry, and academia, NASA will perform systems engineering, technology development and architecture definition trade studies to define at least two 2nd Generation RLV architecture designs that will best meet the requirements to make access to space safer, more reliable, and less expensive for present and future customers. The ongoing 2nd Generation RLV design-and-development activities took into account extensive NASA studies and contractor-provided input from prior solicitations, which focused on detailed requirements evaluation, updated market projections, and risk-reduction priorities and plans. This systematic approach targets the research and development of high-priority advanced technologies—such as lightweight structures, long-life rocket engines, advanced crew systems, life support, robotics, flight control and avionics, and thermal protection systems—to be integrated into at least two launch architectures to provide the foundation for future potential full-scale development decisions in FY 2006. The emphasis is on risk-reduction activities selected according to industry and NASA needs. The high priority risk reduction areas identified included technology development and demonstration, business and program planning, and systems engineering and analysis.

APG 3R6: Down-select to a minimum of two launch architectures for detailed development based on their ability to meet the safety and affordability goals. This selection will determine what launch architectures and critical technology developments will be continued through FY 2006.

Performance Indicators:

- Architecture systems requirements document for 2nd Generation RLV will be baselined
- Successful completion of the 2nd Generation RLV systems requirement review
- Successful completion of the main engine prototype critical design reviews
- Down-select to a minimum of two launch architectures for detailed development

Technical Approach (Future Generation): Significantly increase the inherent reliability, flexibility and intact abort options of future launch systems. This will be achieved primarily by dramatically increasing system margin (performance, weight and operating margins). In addition, NASA will work to reduce the variability and increase the intelligence, redundancy and robustness of future systems. As a critical first demonstration of dramatically increased system margin, NASA will ground validate a rocket based combined cycle engine, ground validate a Mach 4 turbine accelerator for a turbine-based combined cycle engine and flight validate a multi-Mach scramjet and critical supporting technologies and tools by 2007. These concepts utilize oxygen from the atmosphere to greatly increase the efficiency of the propulsion system. NASA will leverage investments of parallel programs to make advances in supporting technologies. Based on these results, a decision will be made on the next steps of flight validating combined cycle propulsion systems. This effort is being conducted in close cooperation and coordination with the DoD as part of the National Hypersonic's Plan.

APG 3R7: Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations and associated ground technologies. This independent evaluation will validate ability of each propulsion system, a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine, to achieve the strategic objectives within cost and schedule.

Performance Indicators:

- Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations, including a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine.
- Demonstrate resin transfer molded polymer matrix composite with 550°F use temperature
- Complete X-43 scramjet launch system preliminary design review
- Complete direct connect injector testing for RBCC engine
- Complete flowpath air augmented rocket for RBCC engine
- Complete water cooled single thruster for RBCC engine

Objective Seven – Mission Affordability: Create an affordable highway to space by reducing the cost of delivering a payload to low-Earth orbit to $1,000 per pound (a factor of 10) by 2010 and to $100 per pound (an additional factor of 10) by 2025 and reducing the cost of inter-orbital transfer by a factor of 10 within 15 years and by an additional factor of 10 by 2025.

Strategy:

- **Reusable and Robust Propulsion Systems:** Develop long-life, highly reusable engine systems and inherently reliable integrated propulsion systems.

- **Low-Cost, Lightweight Materials and Structures:** Reduce the overall system weight of vehicles using lightweight, long-life primary structures and low-cost metallic and non-metallic propellant tanks.
- **Operations Optimization:** Develop the capability for autonomous checkout and vehicle control, modular payload systems, and new launch site operations.
- **Risk Reduction:** Develop key technologies for full-scale development of a second-generation RLV system.

Public Benefit: An affordable earth-to-orbit space transportation system is a key enabler of the commercial development, civil exploration and national security. Human space flight remains an expensive endeavor in spite of advances in aerospace technology. NASA intends to substantially reduce the resources devoted to routine space operations by developing the technologies and architectures for the next generation of RLVs and by concurrently developing the advanced technologies that will be required for future generations of RLV. These future vehicles and their associated systems could enable a broad expansion in scientific research, ensure the seamless security of aerospace, open new commercial markets, increase national security, and enable the human exploration and development of space.

Technical Approach (Next Generation): Building on 20 years of success with America's 1st Generation RLV—the Space Shuttle—the 2nd Generation RLV program defines the plan of action to design and develop America's next-generation RLV. In partnership with the Department of Defense (DoD), the U.S. aerospace industry, and academia, NASA will perform systems engineering, technology development and architecture definition trade studies to define at least two 2nd Generation RLV architecture designs that will best meet the requirements to make access to space safer, more reliable, and less expensive for present and future customers. The ongoing 2nd Generation RLV design-and-development activities took into account extensive NASA studies and contractor-provided input from prior solicitations, which focused on detailed requirements evaluation, updated market projections, and risk-reduction priorities and plans. This systematic approach targets the research and development of high-priority advanced technologies—such as lightweight structures, long-life rocket engines, advanced crew systems, life support, robotics, flight control and avionics, and thermal protection systems—to be integrated into at least two launch architectures to provide the foundation for future potential full-scale development decisions in FY 2006. The emphasis is on risk-reduction activities selected according to industry and NASA needs. The high priority risk reduction areas identified included technology development and demonstration, business and program planning, and systems engineering and analysis.

APG 3R8 Down-select to a minimum of two launch architectures for detailed development based on their ability to meet the safety and affordability goals. This selection will determine what RLV architectures and critical technology developments will be continued through FY 2006.

Performance Indicators:

- Architecture systems requirements document for 2nd Generation RLV will be baselined
- Successful completion of the 2nd Generation RLV systems requirement review
- Successful completion of the main engine prototype critical design reviews
- Down-select to a minimum of two launch architectures for detailed development

Technical Approach (Future Generation): Significantly increase the inherent reliability, flexibility and intact abort options of future launch systems. This will be achieved primarily by dramatically increasing the system margin (performance, weight and operating). In addition, NASA will work to reduce the variability and increase the intelligence, redundancy and robustness of future systems. As a critical first demonstration of dramatically increased system margin, NASA will ground validate a rocket-based combined-cycle engine, ground validate a Mach 4 turbine accelerator for a turbine-based combined cycle engine, and flight validate a multi-Mach scramjet and critical supporting technologies and tools by 2007. These concepts utilize oxygen from the atmosphere to greatly increase the efficiency of the propulsion system. NASA will leverage investments of parallel programs to make advances in supporting technologies. Based on these results, a decision will be made on the next steps of flight validating combined cycle propulsion systems. This effort is being conducted in close cooperation and coordination with the DoD as part of the National Hypersonic's Plan.

APG 3R9 Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations and associated ground technologies. This independent evaluation will validate ability of each propulsion system, a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine, to achieve the strategic objectives within cost and schedule.

Performance Indicators:

- Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations, including a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine.
- Demonstrate reaction transfer molded polymer matrix composite (PMC) with 550°F use temperature
- Complete RBCC Engine Test of a PMC combustor support chamber
- Complete X-43 scramjet launch system preliminary design review
- Complete direct connect injector testing for RBCC engine
- Complete flowpath air augmented rocket for RBCC engine
- Complete water cooled single thruster for RBCC engine

Objective Eight – Mission Reach: Extend our reach in space with faster travel times by reducing the time for planetary missions by a factor of 2 by 2015 and by a factor of 10 by 2025.

Strategy:

- **Advanced Propulsion Concepts:** Identify and develop breakthrough technology for advanced propulsion systems.
- **Materials and Structures:** Develop lightweight airframes, tanks, and micro-components using nano-technology and ultra-high temperature ceramics.

Public Benefit A major NASA objective is the exploration of the solar system to provide the American public with an understanding of the nature, history, and origins of the planets and their moons. Some NASA planetary missions also seek evidence of existing or extinct life at key planets and moons or provide comparative planetary data that helps in the development of accurate, predictive environmental, weather, climate, natural disaster, and natural resource models for Earth. The distance of planetary science targets from Earth is a major obstacle to conducting these missions. Current launch vehicles and on-board chemical propulsion systems require years of transit time with spacecraft in dormant states to reach the outer planets. Once they arrive at a target, mass and power limits imposed by today's propulsion systems further limit the size of planetary mission science instruments. The technologies that are being developed will provide the major breakthroughs are needed to enable science missions that are beyond the limits of chemical systems in order to provide an increased understanding of our neighboring celestial bodies and galactic phenomena and, possibly, explore beyond them.

Technical Approach: The will focus on the discovery and development of high-risk, high-payoff technologies with specific application to enabling rapid interplanetary access. Innovative ideas from the external community, leveraged by emerging technologies outside the aerospace field, will complement NASA capabilities in critical areas. Very advanced concepts with potentially huge improvements over current systems, but that are in early stages of understanding and development, are emphasized. Among the current foci are an electric engine fueled by nuclear fusion, a magnetohydrodynamic (MHD) by-pass, and a Lithium propellant concept. Component and process technologies and performance prediction methods are being developed to enable subsystem test beds that will feed system level test-beds for methods that show promise. Technology products will be integrated into proof-of-concept systems to validate performance in practical applications as practical system emerge over a period expected to be 8-10 years.

APG 3R10 Complete initial component tests to provide data for evaluating feasibility of key concepts by completing all of the following indicators.

Performance Indicators:

- Demonstrate plasma compressors for fusion concept
- Successfully complete arc-shock tunnel tests for magneto-hydrodynamic bypass concept
- Initiate lithium propellant tests
- Complete magnetic nozzle high power (on the order of one gigawatt) test for high temperature plasma

Goal 3 – Pioneer Technology Innovation: Enable a revolution in aerospace systems.

Objective Nine – Engineering Innovation: Enable rapid, high-confidence, and cost efficient design of revolutionary systems by enabling the capability to predict and alleviate with 95 percent confidence, during mission design, all probable threats to mission success by 2012. By 2022 enable the capability to methodically design missions with safety, cost, technical performance, and life defined with 95 percent confidence.

Strategy:

- **Process and Concept Innovation:** Develop new processes and concepts for accomplishing full-life-cycle ("cradle-to-grave") planning and design of new, revolutionary aerospace systems.
- **Validation and Implementation:** Develop technologies and concepts for new ways of certifying and fielding new aerospace systems.
- **Information Technologies:** Develop computational capabilities and knowledge bases necessary to design new aerospace systems.

- **Advanced Engineering and Analysis Technologies:** Develop design tools and the ability to model any part of a new vehicle design during any part of the system's span and under all operating conditions and environments.

Public Benefit: Reduced cost and increased reliability and safety of aerospace systems.

Technical Approach: Two programs contribute to the accomplishment of this strategic goal. The Engineering for Complex Systems Program will develop comprehensive capabilities and components for knowledge access, model based reasoning, risk prediction & management, experience capture, software engineering tools, resilient software-based systems and design decision-making. Methods will be developed for integrating advanced system health measurement approaches in the design process that take advantage of current and future developments in on-board sensing, self-healing materials, and self-reliant systems.

The Computing, Information, and Communications Technology Program will develop technologies to provide seamless and collaborative access to distributed ground-, air-, or space based hardware resources. It will also develop technologies to provide seamless and collaborative access to distributed software resources, whether they are in the form of data, tools, processes, or knowledge. This will allow better sharing of information, improves tracking of assumptions about complex processes, and reduce time spent on hardware and software integration. These prediction, modeling, and design capabilities will be integrated into a progressively improving set of user-accepted tools that can enable reliable design for mission safety and accurate assessment of mission cost and performance. Broadly announced peer reviewed solicitations are used to capture innovative ideas from the external community and to leverage emerging technologies from outside the aerospace field. These concepts will be combined with NASA expertise to synergistically form the basis for generating research programs in current critical areas and identifying new areas for research. Technology products will be integrated into proof-of-concept systems to validate performance in practical applications.

APG 3R11: Complete development of an organizational risk model and establish initial high dependability computing testbeds and tools as defined in the following indicators.

Performance Indicators:

Process and Concept Innovation

- Complete initial Organizational Risk Model that captures and analyzes data on social/organizational system risks and manage and evolve the organization by enabling the description and analysis of risks in organizational level decisions

V**alidation and Implementation**

- Establish initial High Dependability Computing Testbeds - install, load and provide initial simulations for at least two key NASA software systems that mitigate risks in the areas of dependability, performance/risk measurement tools, and testing of complex intelligent systems.
- Demonstrate certifiable program synthesis technology

Advanced Engineering and Analysis Technologies

- Validate nonlinear structural analysis tools

Objective Ten – Technology Innovation: Enable fundamentally new aerospace system capabilities and missions by enabling a 500 percent increase in useful new science information acquired from NASA science missions, data sources, and science system simulations as compared to equivalent FY 2000-2002 science programs by 2012, and by 2022, a 1000 percent increase. Enable heretofore-impractical or unaffordable mission classes by improving, by a factor of 3 in 2012 and 10 in 2020 over comparable systems and concepts designed using FY 2000 – 2002 flight –ready technology, flight resources including payload mass, volume, and power. By FY 2012, enable mission systems that can operate safely and successfully with less than 10 percent of the human participation required for FY 2000-2002 designs, and by FY 2020 enable missions that can analyze unexpected events and adjust plans and adapt systems accordingly with no human participation.

Strategy:

- **Core Competencies:** Build and advance, within NASA, the technology competencies that have potential for major benefits to aerospace applications.
- **Enabling New Missions:** Develop technologies for missions that are currently unrealistic, from personal air transportation to interstellar travel. This thrust will remove barriers such as high technology costs, limits to human endurance, and immense mission timeframes, to open exciting new possibilities.
- **Enabling New Capabilities:** Develop capabilities that are not possible today, such as autonomy sufficient to conduct an entire mission without human intervention, or self-repair of a vehicle's skin.

Public Benefit: NASA's science objectives are to answer diverse and far-reaching scientific questions regarding the universe, galaxies, stars, and planets including their make-up, origins, and the physical, chemical and biological processes involved. These include understanding the Earth and Sun and modeling the complex processes and interactions of the two to provide models of weather, climate, natural disaster, and natural resources for the improvement of the quality of life on earth. The total range of observations, measurements, and data analyses needed to address these objectives far exceeds the capabilities and affordability of current capabilities. The Aerospace Technology Enterprise seeks to provide radical improvements in sensing, instrument, and data processing technologies that are applicable to broad classes of science missions that can obtain information not currently attainable and to provide needed information at a lower cost.

NASA is developing revolutionary technologies for sensing and spacecraft systems to provide increased scientific return from future missions at lower cost. Advanced technologies will allow NASA to explore new regions of space, and to gain greater knowledge of the Earth, the Solar System, and the Universe. More capable and cost-effective missions will provide a higher return on investment in NASA programs over the next decade. NASA research in this program could also lead to lighter weight, higher strength materials for commercial applications, power concepts for remote locations, and very small biochemical probes applicable to medicine.

A huge cost factor in the operation of aerospace systems, once they are deployed, is the workload and cost of human operators whether it be for air traffic control, Space Shuttle launch, Space Station operation, or the monitoring and control of science missions. Science missions are frequently terminated, even though the spacecraft is operating perfectly and has considerable remaining life, because the cost of operation is too high relative to the remaining scientific potential. The workload and danger to astronauts in operating current and future exploration missions is a serious concern. Operating spacecraft on planetary surfaces and behind planets and moons is dangerous to mission success without the ability for the spacecraft to react to unplanned events.

Systems will be developed that can think, team, and make decisions with minimum human involvement to enable space exploration at far lower cost in human resources and to far more inaccessible locations than is currently possible. In addition to enabling breakthrough opportunities for space missions, this technology could improve many aspects of life on earth, for example, automating complex or hazardous work environments such as mining, rescue in natural disasters, or underwater operations.

With the vast amounts of scientific data being returned to Earth for analysis, another critical area of importance for NASA is in the area of data mining and data understanding. Tools and techniques are required to automatically analyze the data and to extract relevant scientific features for further human analysis and knowledge extraction. In addition to feature recognition and extraction, a key goal of this technology is to provide the underlying basis for establishing causal effects through modeling that can be used for analysis and study of the underlying physical or biological phenomena.

Finally, new revolutionary technologies in distributed information environments are required to enable much of the key capabilities discussed above. Seamless access to ground-, air- and space-based data and information are needed for effective command and control of NASA's exploration assets, optimal science return and knowledge generation, and for engineering and scientific collaborations. This distributed information environment will also benefit many other aspects of human life including other areas of science discovery and key operational environments such as the National Air Space system.

Note on APG's for Technology Innovation objective: The research and technology development supporting the Technology Innovation objective is necessarily about discovery; that is, exploring new ideas that may have high payoffs, but are also high-risk because outcomes and the timing of the outcomes that are unknown. Without being able to predict these outcomes, yet ensure advances in the state-of-the-art, numerous ideas from numerous sources are investigated. The few ideas that are successfully implemented typically result in enabling new, in some cases, unexpected functionality in future systems, including sensors, spacecraft or missions. If we fail to meet an indicator, it does not preclude the state-of-the-art from being advanced on the attempt. The following APG's for the Technology Innovation objective are to "advance the state-of-the-art."

Technical Approach (Science Data): Develop fundamental advances in automated reasoning technologies for spacecraft and rover autonomy and mission planning and scheduling. Develop fundamental advancements in instrument and data delivery capabilities, such as sensitivity, spatial coverage, resolution, spectral bandwidth and selectivity, data delivery rate, and data quality that vastly expand the reach of space and earth science in observable phenomena, physical space/time, and information richness. Seek bold new approaches to measurement, sensing, and decision processes though new concepts in bio-/nano-/information technology. Develop breakthrough capabilities for accessing, analyzing, and applying new and existing science data and for simulating systems to increase quality, timeliness, and understanding of information obtained. Develop breakthrough capabilities for data fusion and synthesis (e.g. for combining data from experiment and computation) and for data, information and knowledge mining. Broadly announced peer reviewed solicitations are used to capture innovative ideas from the external community, to leverage emerging technologies outside the aerospace field, and to complement NASA capabilities in critical areas. Technology products are integrated into proof-of-concept systems to validate performance in practical applications. Potential NASA mission customers are involved in the technology planning process and co-funded partnerships with user Enterprises for transition of maturing technologies to mission applications are pursued actively.

APG 3R12: Advance the state-of-the-art in automated data analysis, mission command and communications, and science sensors and detectors that are potentially beneficial for future NASA missions.

Performance Indicators:

Automated Science Data Understanding

- Discover a novel feature in skewed data
- Demonstrate tools and techniques for automated feature extraction from large datasets
- Demonstrate distributed analysis and data processing to support new problem solving paradigms
- Demonstrate component autonomy technologies in planning and scheduling supporting Mars mission operations

Mission Command and Data Delivery

- Demonstrate technology capable of two-times improvement in Mars-to-Earth communications
- Demonstrate technology capable of ten-fold improvement in Earth-orbit to ground communications
- Demonstrate capability for ad-hoc space and surface networking

Science Sensors and Detectors

Demonstrate molecular-level sensors for environmental health monitoring
Demonstrate high-efficiency, tunable, narrow-line 2 micron laser transmitters

- Demonstrate a fully conductively cooled laser transmitter

Characterize 2 micron detector and receiver components

- Perform advanced quantum mechanical modeling and spectroscopy of laser systems
- Demonstrate photonic/electronic hybrid power devices compatible with flexible substrates
- Demonstrate terahertz amplifiers with gain above 500 gigahertz
- Demonstrate superconducting terahertz receivers
- Demonstrate a prototype liquid Helium 4° Kelvin miniature sorption cooler
- Demonstrate 20 channel radio frequency single electron transistor multiplexor
- Demonstrate a prototype 256x256 Gallium Nitride Schottky photodiode array
- Demonstrate a prototype 512x512 prototype MicroElectroMechanical Systems (MEMS) microshutter array
- Demonstrate a prototype continuous Adiabatic Demagnetization Refrigerator at less than 0.1 degree Kelvin

Technical Approach (Ultra Efficiency): NASA will focus on the development of high-risk, high-payoff technologies with broad application to many classes of missions. These technologies are unique to NASA's long-term needs, and are not being developed elsewhere. Fundamental research and development will be performed in a variety of technical areas, including micro-devices and sensors, on-board power, electric propulsion, structures and materials, and bio-nanotechnology. To reduce cost and enhance scientific capabilities, technology development will emphasize miniaturization and launch-packaging efficiency, integration of functions, frugal use of flight resources, and resiliency. Broadly announced peer-reviewed solicitations are used to capture innovative ideas from the external community, to leverage emerging technologies outside the aerospace field, and to complement NASA capabilities in critical areas. Technology products are integrated into proof-of-concept systems to validate performance in practical applications. Potential NASA mission customers are involved in the technology planning process and co-funded partnerships with user Enterprises for transition of maturing technologies to mission applications are actively pursued.

APG 3R13: Advance the state-of-the-art in power / propulsion systems, spacecraft systems, and large or distributed space systems and our knowledge of space environmental effects that are required to support future NASA missions.

Performance Indicators:

Advanced Power and Electric Propulsion Systems

- Validate ion optics for a 2X increase in life relative to Deep Space 1
- Complete Hall thruster life and operating point correlations
- Complete Hall thruster modeling
- Demonstrate feasibility of high efficiency (i.e., greater than 30 percent) multi-band-gap solar cell on silicon substrate
- Demonstrate single axis integrated momentum and power control with flywheels
- Demonstrate 100 percent thrust augmentation of high area ratio nozzle
- Complete laboratory characterization of solid hydrogen behavior in liquid helium

Micro and Multipurpose Spacecraft Components and Systems

- Demonstrate integrated micropropulsion subsystem with control electronics
- Demonstrate three-axis inertial measurement unit using microgyros
- Demonstrate alpha voltaic power microgenerator
- Demonstrate integrated microinductors for miniature voltage converter
- Demonstrate sun sensor on chip for microspacecraft navigation
- Demonstrate micro electromechanical system microvalve
- Demonstrate 200 watt-hours per kilogram multifunctional battery/spacecraft structure panel

Large and Distributed Space Systems Concepts

- Develop algorithms for attitude determination for spacecraft formations using Global Positioning System (GPS)
- Develop algorithms for attitude control of spacecraft formations using GPS
- Develop relative equations of motion for spacecraft formations at L2 libration point
- Identify viable new concepts for in-space assembly of large space systems
- Demonstrate a prototype membrane waveguide antenna for remote sensing
- Demonstrate the deployment and ultraviolet-rigidization of inflatable boom for solar sails in a laboratory environment
- Demonstrate the deployment of a space boom using shape-memory-composite materials
- Establish proof of concept for a printable electronic circuit on multifunctional membranes

- Demonstrate a prototype electric powered unpiloted air vehicle capable of sustaining 14 hours of operation above an altitude of 50,000 feet

Space Environments and Effects

- Deliver meteoroid environmental model for inner solar system, Venus, and Mars
- Deliver revised NASA / Air Force Spacecraft Charging Analyzer Program (NASCAP-2K, Version 2.0)
- Develop Electronic Properties of Materials Database for use by spacecraft charging models and materials engineers
- Deliver Magneto-tail Charged Particle model for materials degradation studies
- Deliver Low Earth Orbit Spacecraft Charging Guidelines
- Deliver initial state of the art materials knowledge base (SAM-K, Version 1.0)

Technical Approach (Self Reliance): Develop technologies that can enable systems and systems of systems that can think, reason, make decisions, adapt to change, and cooperate among themselves and with humans to provide safe and successful aerospace processes and mission functions with greatly reduced human participation in their execution. Technology products will be integrated into proof-of-concept systems to validate performance in practical applications. Broadly announced peer-reviewed solicitations are used to capture innovative ideas from the external community, to leverage emerging technologies outside the aerospace field, and to complement NASA capabilities in critical areas. Technology products will be integrated into proof-of-concept systems to validate performance in practical applications.

APG 3R14: Demonstrate progress toward achievement of systems and systems of systems that can think, reason, make decisions, adapt to change, and cooperate among themselves and with humans to provide safe and successful aerospace processes and mission functions with greatly reduced human participation by successfully demonstrating individual autonomy components.

Performance Indicator

- Demonstrate individual autonomy component technologies to be included in the larger, integrated demonstration

5. Management Challenges: The overall organizational and management structure of NASA technology development is built around its Strategic Enterprises, including specific program formulation and funding responsibility for all technology activities. This ensures that technology considerations are closely coupled with mission decisions, that technologies are relevant to Enterprise needs, and that mechanisms are provided to transfer successful maturing technologies into operational systems. NASA has undertaken sweeping changes in technology program management to strengthen and highlight the significance of advanced technology in NASA's future. These changes influence how NASA identifies new technology investments and how NASA ensures the efficient transition of new technologies into missions. Specifically, this includes: the realignment of the budget to more closely correspond with Enterprise Strategic Objectives, development and implementation of system analysis tools to aid in program assessment and development of technology portfolios, use of the Aerospace Technology Advisory Committee of the NASA Advisory Council and the National Research Council to provide independent relevance and quality reviews of the Enterprise's technology development projects, and strengthening the relationships with other NASA Enterprises in the development of the research program, and participation in technology maturation activities. Overall, the adjustments have resulted in a closer alignment of technology investments with the goals identified in the NASA Strategic Plan and will allow management to assess the quality and relevance of the Enterprise's research program.

Coordination and integration among all of the Agency's Enterprises is provided through the NASA Chief Technologist. The Chief Technologist advises the Administrator and other senior officials on matters relating to technology, assures an Agency-wide investment strategy for advanced innovative technology, and is the principal Agency advocate for advanced technology. The Chief Technologist also chairs the Technology Leadership Council, which includes the Associate Administrators for the Strategic Enterprises, the NASA Field Center Directors, the NASA Comptroller, and other senior NASA officials. This council establishes the technology strategy for the Agency, addresses critical issues, and is responsible for formulating and advancing NASA's vision for technology. The Associate Administrator for Aerospace Technology is the NASA Chief Technologist to centralize planning and execution of Agency-level technology within one organization while still providing for Enterprise-specific mission technology development by each of the other NASA Enterprises.

As part of the development of the FY 2003 budget development, the Aerospace Technology Enterprise has restructured its programs and projects to more closely align with its Strategic Objectives. This revised structure will simplify the management structure and increase responsiveness to the customer communities.

The Enterprise will also be using independent reviews to provide external assessments of its programs. In total these reviews will assess the programmatic status of each of the programs, the progress that the Enterprise is making toward the achievement of its strategic objectives, the scientific quality of its research, and relevance of the research to the customer's needs. The results of these reviews will provide the Enterprise with objective information on the status and effectiveness of its research programs and impact the content and future elements of the program. Each of these reviews is discussed below.

- An Inter-Center System Analysis Team has been formed and conducts an independent assessment of the progress the Enterprise is making toward the accomplishment of each of its strategic objectives. System analysis tools have been developed to support this process, which will provide the Enterprise with a benchmark for measuring its overall progress toward the accomplishment of its Strategic goals.

- An Independent Annual Review (IAR) will be performed to assess the progress and continued executability of each Enterprise program the annual program review will assess performance against plan, including technical performance, schedule and cost. Additionally the IAR will assess the future executability of the program plan. The IAR compiles its report and provides findings to the Enterprise and governing Program Management Council.

- The quality and relevance review process includes two separate and independent review mechanisms.

- The NASA Advisory Council Aerospace Technology Advisory Committee (ATAC) will conduct an annual review of the relevance and quality of Aerospace Technology Enterprise programs with emphasis on relevance. This review will provide input from our primary customers on the relevancy of our program to their needs and the agency goals.

- The National Research Council Aeronautics and Space Engineering Board (ASEB) will conduct periodic review of the quality and relevance of each Aerospace Technology Enterprise project with emphasis on quality. This review will assess: the scientific and technical quality of each research project, the quality of the performers conducting the research, whether the proper mix of personnel from government, industry, and academia are assigned to each project, the relevance of each project to the customer, and the quality of the program planning behind each project. The team will examine the research portfolio, the research goals, the research plans, the overall capabilities of the research team, the technical progress and prognosis of the research, and the relationship of the research to the broader scientific community.

The management challenges facing the Aerospace Technology Enterprise are similar to that of any organization that is responsible for the identification and development of revolutionary and high-risk technologies for a wide range of using organizations. These include:

- Ensuring that the user needs are well understood, reflected in the research plans and that the user also recognizes the benefits of the on-going research
- Ensuing research being conducted in the proper areas and that the far term research being conducted at the forefront of science and determined to be a world-class endeavor
- Ensuring that research is being conducted by the proper performer (government, academia, or industry).
- Ensuring the proper balance between fundamental and user driven research
- Ensuring that there is the proper balance between far term research and the application of fundamental science to solve real world problems
- Ensuring that the research plans are sound (including regular external reviews, off-ramps, and sunsets) and that adequate progress is being made toward the end objective
- Ensuring effective knowledge transfer

The Office of Aerospace Technology has established the following goals to address the above management challenges. The accomplishment of these goals is on an Enterprise wide basis since they address the totality of the research program and not individual goals / objectives.

APG 3R15: Implement an effective oversight process to insure that the research programs are addressing the correct areas, meeting user requirements, have the proper balance, are properly formulated and planned, and are making sufficient process toward the Enterprise goals

Performance Indicators:

Strategic Planning and Decisions

- Effective use of the Office of Aerospace Technology Investment Planning process to assess the needs against the current research portfolio and identify potential technology gaps
- Conducting a inter center system analysis to assess the progress the current research portfolio is making toward the accomplishment of the Enterprise Strategic Objectives

Program Quality and Relevance

- Conducting independent technical reviews to assess the relevance and quality of selected items of the research program. The reviews will examine the research portfolio, goals and the relationship to the broader scientific community, in terms of the quality of the technology being developed and the needs of the customer organizations.

- Establishment of a review team consisting of representatives of the customer NASA Enterprises and their mission programs and projects to conduct NASA mission relevancy reviews of the research program.

Program Management and Oversight

- Effective use of an Enterprise Program Management Council with appropriate representation from other NASA Enterprises and Offices
- Successful completion of a Program Readiness Review and Non-Advocate Review for every new program / project prior to program go-ahead
- Conducting an Independent Annual review (IAR) of each program to assess its progress and continued executability. The annual program review will assess performance against plan including technical performance, schedule, and cost. Additionally, the IAR will assess the future executability of the program.

APG 3R16: To contribute toward maintaining a well-prepared workforce pipeline, all Enterprise program activities will establish and implement, or continue implementation of, an education outreach plan that results in an educational product. The product shall be consistent with the NASA Implementation Plan for Education and use program content to demonstrate or enhance the learning objectives.

Performance Indicators:

- Implementation of current education outreach plans.
- Establishment of education outreach plans for all remaining programs
- Effective use of the 5 University-based Research, Education, and Training Institutes (RETIs).
- Inclusion of a University research strategy for each Enterprise program

Verification/Validation Summary: The data used to substantiate actual performance originates at the NASA Center responsible for project implementation. The data will be reviewed and verified by senior Center official and the program and project managers. The NASA HQ Program Executive Officer and Director of the Research and Technology Division will validate this data. The NASA Advisory Council will also provide an independent assessment of each Aerospace Technology program performance.

FY 2003 MULTI-YEAR PERFORMANCE TREND

Aerospace Technology

Goal 1: Revolutionize Aviation

Strategic Objective: Increase Safety-Make a safe air transportation system even safer

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	9R5: For the aviation safety areas of Controlled Flight into Terrain, runway incursion, and loss of control, identify the contributing causes to be addressed, potential solutions using current capabilities, and gaps that require technology solutions.	0R3: Flight demonstrate a conceptual aircraft flight deck integrated with evolving ground-based runway incursion avoidance technologies installed at a major airport.	1R1: NASA's research stresses aviation system monitoring and modeling, accident prevention and accident mitigation. The performance target is to complete 75% of the conceptual designs of systems for preventing and mitigating accidents, and to demonstrate tools for accident analysis and risk assessment.
Assessment	Green	Yellow	
Annual Performance Goal and APG #	9R2: Characterize the Super-cooled Large Droplets (SLD) icing environment, determine its effects on aircraft performance, and acquire and publish data to improve SLD forecasting confidence.		
Assessment	Yellow		
	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R1: Complete the interim progress assessment utilizing the technology products of the Aviation Safety program as well as the related Aerospace Base R&T efforts and transfer to industry an icing CD-ROM, conduct at least one demonstration of an aviation safety related subsystem, and develop at least two-thirds of the planned models and simulations.	APG 3R1: Demonstrate progress in maturing, through flight tests and/or simulations, the critical technologies that will be necessary to meet the aviation safety objective. These tests and simulations are critical steps in the development of a suite of technologies that when completely developed and implemented by the customer, will provide a minimum of 50 percent reduction in fatal accident rate.	
Assessment	TBD	TBD	

Strategic Objective: Reduce Emissions-Protect local air quality and our global climate

	FY 99	**FY 00**	**FY01**
Annual Performance Goal and APG #	9R1: Demonstrate an advanced turbine-engine combustor that will achieve up to a 50 percent reduction of Oxides of Nitrogen emissions based on 1996 International Civil Aviation Organization (ICAO) standards.	0R1: Demonstrate, in a laboratory combustion experiment, an advanced turbine-engine combustor concept that will achieve up to a 70% reduction of oxides of nitrogen emissions based on the 1996 ICAO standard.	1R2: NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen and carbon dioxide. The performance target is to complete one system level technology benefit assessment, one component concept selection and one new material system.
Assessment	Green	Blue	
	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R2: NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen (NOx) and carbon dioxide (CO2). The annual performance goal is to complete sector testing of a low-NOx combustor concept capable of a 70% reduction in NOx from the 1996 International Civil Aviation Organization (ICAO) baseline, and demonstrate at least one additional concept for the reduction of other emittants.	APG 3R2: Complete combustor sector test for concepts capable of achieving the 70%NOX goal by 2007 and select the most promising approaches leading to full annular rig testing for large and regional jet engine applications. Complete an Interim Technology Assessment of the aggregate potential benefits from the engine and airframe technologies to reduce emissions. The results from this analysis will provide a benchmark for measuring overall progress, and guide future investment decisions.	
Assessment	TBD	TBD	

<u>Strategic Objective</u>: Reduce Noise-Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers

	FY 99	**FY 00**	**FY01**
Annual Performance Goal and APG #		0R2: Validate the technologies to reduce noise for large commercial transports by at least 7 decibels relative to 1992 production technology.	1R3: NASA's research has stressed reducing noise in the areas of engines, nacelles, engine/airframe integration, aircraft interiors and flight procedures. The performance target is completion of NASA's research in noise reduction through large scale demonstration of a 2-5 decibel reduction in aircraft noise based on 1997 production technology, and initial assessments of concepts offering additional reduction.
Assessment		Green	
	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R3: NASA's research stresses reducing noise in the areas of engines, nacelles, engine-airframe integration, aircraft interiors and flight procedures. The annual performance goal is to assess and establish the strongest candidate technologies to meet the 10 decibel reduction in community noise.	APG 3R3: Complete development of initial physics-based prediction models to guide the development potential noise reduction technology concepts. Complete an interim technology assessment of the potential benefits for these concepts to reduce noise emissions. The results from this analysis will provide a benchmark for measuring overall progress, and guide future investment decisions.	
Assessment	TBD	TBD	

<u>Strategic Objective</u>: Increase Capacity-Enable the movement of more air passengers with fewer delays

	<u>FY 99</u>	**<u>FY 00</u>**	**<u>FY01</u>**
Annual Performance Goal and APG #		0R4: Conclude the Terminal Area Productivity project by field demonstrations of the complete suite of technologies and procedures that enable a 12% increase over 1994 nonvisual operations for single-runway throughput.	1R4: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The performance target is to complete the civil tiltrotor project by validating databases for contingency power, flight paths, and noise reduction, as well as complete at least one demonstration of an airspace management decision support tool.
Assessment		Green	
	<u>FY 02</u>	**<u>FY 03</u>**	
Annual Performance Goal and APG #	2R4: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The annual performance goal is to develop a decision support tool, and define concepts for future aviation systems.	APG 3R4: Complete development, initial functionality and evaluate human factors for at least one decision support tool to enable achievement of the planned progress towards the goal of doubling the capacity of the National Airspace System in 10 years. Complete the initial build of a toolbox of state-of-the-art airspace models to enable the planned progress towards the 2022 Objective.	
Assessment	TBD	TBD	

Strategic Objective: Increase Mobility-Enable people to travel faster and farther, anywhere, anytime

	FY 99	**FY 00**	**FY01**
Annual Performance Goal and APG #	9R8: Conclude pre-flight ground testing of the general aviation piston and turbofan engines.	0R7: Perform flight demonstrations of advanced general aviation piston and turbine engines at the annual Oshkosh air show.	1R7: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The performance target is to complete the Advanced General Aviation Transport Experiments project by validating transportation system concepts through flight test and publish design guidelines.
Assessment	Yellow	Yellow	
Annual Performance Goal and APG #	9R6: Produce a complete vehicle system configuration document that includes impact of technology validation efforts from 1990 through 1999. This document will support the evaluation of technology selection decisions for a future High Speed Civil Transport (HSCT).		
Assessment	Green		

	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R5: NASA's research stresses aircraft technologies which enable the use of existing small community and neighborhood airports, without requiring control towers, radar installations, and more land use for added runway protection zones. The annual performance goal is to baseline, in partnership with the FAA, the system engineering	APG 3R5: Select candidate technologies for experimental flight evaluation based on their impact on mobility. Mobility metrics will be measured by accessibility, doorstep-to-destination transit time, system and user costs, and related trip reliability and safety metrics. These flight experiments will evaluate individually, at the sub-system level, the impact of selected technologies on lowering required landing minimums and increasing the volume of operations at	
Assessment	TBD	TBD	

Goal 2: Advance Space Transportation

Strategic Objective: Mission Safety-Radically improve the safety and reliability of space launch systems

	FY 99	FY 00	FY 01	
Annual Performance Goal and APG #				
Assessment				

	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R6: NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews to support design and demonstration decisions.	APG 3R6: Down-select to a minimum of two launch architectures for detailed development based on their ability to meet the safety and affordability goals. This selection will determine what launch architectures and critical technology developments will be continued through FY 2006.	
Assessment	TBD	TBD	
Annual Performance Goal and APG #		APG 3R7: Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations and associated ground technologies. This independent evaluation will validate ability of each propulsion system, a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine, to achieve the strategic objectives within cost and schedule.	
Assessment		TBD	

<u>Strategic Objective</u>: Mission Affordability-Create an affordable highway to space

	<u>FY 99</u>	**<u>FY 00</u>**	**<u>FY01</u>**
Annual Performance Goal and APG #	9R14: Continue the X-33 Vehicle Assembly in Preparation for Flight Testing.	0R9: Conduct the flight testing of the X-33 vehicle.	1R10: NASA's research stresses highly reliable, fully reusable configurations, advanced materials and innovative structures. The performance target is complete assembly of the third X-34 test vehicle, demonstrate 75% of supporting technology developments, and complete competitive solicitations for expanded 2nd generation reusable launch vehicle efforts.
Assessment	Green	Red	
Annual Performance Goal and APG #	9R15: Complete Vehicle Assembly and Begin Flight Testing of the X-34.	0R12: Complete vehicle assembly and begin the flight test of the second X-34 vehicle.	1R11: NASA's research stresses technology for reusable, long life, high power electric and advanced, clean chemical engines for earth orbital transfer and breakthrough propulsion, precision landing systems and aerocapture systems for planetary exploration. The performance target is to commence X-37 vehicle assembly, and complete one Pathfinder flight experiment.
Assessment	Yellow	Red	
Annual Performance Goal and APG #			
Assessment			
Annual Performance Goal and APG #		0R17: Complete small payload focused technologies and select concepts for flight demonstration of a reusable first stage (Bantam).	
Assessment		Red (project terminated 10/99)	

<u>Strategic Objective</u>: Mission Affordability-Create an affordable highway to space (cont.)

	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R7: NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews and initial hardware demonstrations to support design and demonstration decisions.	APG 3R8 Down-select to a minimum of two launch architectures for detailed development based on their ability to meet the safety and affordability goals. This selection will determine what RLV architectures and critical technology developments will be continued through FY 2006.	
Assessment	TBD	TBD	
Annual Performance Goal and APG #			
Assessment		TBD	
Annual Performance Goal and APG #		APG 3R9 Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations and associated ground technologies. This independent evaluation will validate ability of each propulsion system, a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine, to achieve the strategic objectives within cost and schedule.	
Assessment		TBD	
Annual Performance Goal and APG #			
Assessment			

Strategic Objective: Mission Reach-Extend our reach in space with faster travel times

	FY 99	**FY 00**	**FY01**
Annual Performance Goal and APG #		0R10: Complete NASA Solar Electric Propulsion Technology Application Readiness (NSTAR) Mission Profile (100% design life) ground testing for Deep Space-1 (concurrent, identical firing of an NSTAR engine in a vacuum chamber with the actual firing sequence of the in-flight propulsion system).	
Assessment		Green	
	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R8: NASA's long-term research emphasizes innovative propulsion systems. The performance target is to conduct a test of an advanced ion propulsion engine.	APG 3R10 Complete initial component tests to provide data for evaluating feasibility of key concepts by completing all of the following indicators.	
Assessment	TBD	TBD	

Goal 3: Pioneer Revolutionary Technology

Strategic Objective: Engineering Innovation-Enable rapid, high-confidence, and cost efficient design of revolutionary systems

	FY 99	**FY 00**	**FY01**
Annual Performance Goal and APG #	9R12: Demonstrate up to a 200-fold improvement over the 1992 baseline (reduction from 3,200 hours to 15) in the timeto-solution for a full combustor simulation on NASA's National Propulsion System Simulation advanced applications computational testbeds that can be increased to sustain teraFLOPS capability.	0R8: Demonstrate a prototype heterogeneous distributed computing environment.	1R8: Develop at least three new design tools, accomplish at least four demonstrations of advances in computation and communications, and complete the intelligent synthesis environment proof-of-concept system capability build to technology readiness level
Assessment	Blue	Green	
Annual Performance Goal and APG #	9R13: Demonstrate communication testbeds with up to 500-fold improvement over the 1996 baseline (increase from 300 kilobits per second to 150 megabits per second) in end-to-end performance.		
Assessment	Blue		
	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R9: NASA's investments emphasize advances in experimental vehicles, flight testbeds, and computing tools to enable revolutionary designs. The annual performance goal is to conduct at least five demonstrations of revolutionary aerospace subsystems.	APG 3R11: Complete development of an organizational risk model and establish initial high dependability computing testbeds and tools as defined in the following indicators.	
Assessment	TBD	TBD	

<u>Strategic Objective</u>: Technology Innovation-Enable fundamentally new aerospace system capabilities and missions.

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	9R10: Complete low altitude flights of an Remotely Piloted Aircraft (RPA) with a wingspan greater than 200 feet, suitable for flight to 100,000 feet in altitude once outfitted with high performance solar cells.	0R11: Demonstrate improved remotely piloted aircraft science mission capability by increasing operational deployment time from 3 weeks to 9 with minimum airfield provisions and unrestricted airspace. (Original) Demonstrate continuous over-the-horizon command and control capabilities ofan RPA that would extend the operating range from 40 to 200 nautical miles. (Replacement)	
Assessment	Green	Red (orig.); Green (replacement)	
Annual Performance Goal and APG #	9R11: Conduct RPA flight demonstration to validate the capability for science missions of greater than 4 hours duration in remote deployments to areas such as the polar regions above 55,000 feet.		
Assessment	Green		
Annual Performance Goal and APG #		0R6: Demonstrate in flight an airframe-integrated, dual-mode, scramjet-powered vehicle.	1R9: NASA's research stresses affordable flight demonstrations of revolutionary vehicle concepts (low-cost X-Planes) to accelerate technology advances in laboratory research, new design tools and advanced simulation. The performance target is to demonstrate two new concepts in flight and identify five new concepts for further examination.
Assessment		Yellow	

<u>Strategic Objective</u>: Technology Innovation-Enable fundamentally new aerospace system capabilities and missions. (cont.)

	FY 02	**FY 03**	
Annual Performance Goal and APG #	2R10: NASA's investments emphasize revolutionary technologies such as nanotechnology, information technology and biotechnology which could enable new missions and capabilities. The annual performance goal is to develop at least two new materials concepts and demonstrate the feasibility of at least two nanotechnology concepts and two other concepts.	APG 3R12: Advance the state-of-the-art in automated data analysis, mission command and communications, and science sensors and detectors that are potentially beneficial for future NASA missions.	
Assessment	TBD	TBD	
Annual Performance Goal and APG #		APG 3R13: Advance the state-of-the-art in power / propulsion systems, spacecraft systems, and large or distributed space systems and our knowledge of space environmental effects that are required to support future NASA missions.	
Assessment		TBD	
		APG 3R14: Demonstrate progress toward achievement of systems and systems of systems that can think, reason, make decisions, adapt to change, and cooperate among themselves and with humans to provide safe and successful aerospace processes and mission functions with greatly reduced human participation by successfully demonstrating individual autonomy components.	

Management Challenge objective

	FY 99	FY 00	FY01
Annual Performance Goal and APG #	9R16: Complete 90 percent of all Enterprise-controlled milestones within 3 months of schedule.	0R13: Complete 90 percent of all Enterprise-controlled milestones within 3 months of schedule.	
Assessment	Yellow	Red	
Annual Performance Goal and APG #	9R17: Achieve a facility utilization customer satisfaction rating of 95 percent of respondents at "5" or better and 80 percent at "8" or better based on exit interviews.	0R14: Achieve a facility utilization customer satisfaction rating of 95% of respondents at "5" or better and 80% at "8" or better, based on exit interviews.	
Assessment	Blue	Green	
Annual Performance Goal and APG #	9R18: Complete the Triennial Customer Satisfaction Survey, and achieve an improvement from 30 percent to 35 percent in "highly satisfied" ratings from Enterprise customers.		1R12: Customer Feedback: Continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.
Assessment	Green		
Annual Performance Goal and APG #	9R19: Transfer at least 10 new technologies and processes to industry during the fiscal year.	0R15: Transfer at least 12 new technologies and processes to industry during the fiscal year.	
Assessment	Blue	Blue	
Annual Performance Goal and APG #	9R21: For all new program activities initiated in FY 99, develop an education outreach plan, which includes and results in an educational product. This product shall be consistent with current educational standards and use program content to demonstrate	0R16: Continue the implementation of current education outreach plans and establish new plans for all new program activities initiated in FY 00.	1R13: Education Outreach: Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2001.
Assessment	Yellow	Blue	
Annual Performance Goal and APG #	9R20: Establish an Aeronautics Education Laboratory in at least three new sites in the United States.		
Assessment	Blue		

Management Challenge objective (cont.)

	FY 02	FY 03	FY04
Annual Performance Goal and APG #			
Assessment			
Annual Performance Goal and APG #			
Assessment			
Annual Performance Goal and APG #	2R11: The annual performance goal is to continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.	APG 3R15:. Implement an effective oversight process to insure that the research programs are addressing the correct areas, meeting user requirements, have the proper balance, are properly formulated and planned, and are making sufficient process toward the Enterprise goals	
Assessment	TBD	TBD	
Annual Performance Goal and APG #	2R13: Review results of NASA and commercial-sector performed launch system architecture studies, related requirements, and refinements in planned risk reduction investments.		
Assessment	TBD		
Annual Performance Goal and APG #	2R12: Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2002.	APG 3R16: To contribute toward maintaining a well-prepared workforce pipeline, all Enterprise program activities will establish and implement, or continue implementation of, an education outreach plan that results in an educational product. The product shall be consistent with the NASA Implementation Plan for Education and use program content to demonstrate or enhance the learning objectives.	
Assessment	TBD	TBD	
Annual Performance Goal and APG #			
Assessment			

Aerospace Technology **FY 2003 Budget Link Table**	**Budget Category**	Vehicle Systems	Aviation safety	Airspace Systems	2nd Generation	3rd Generation	Engineering for Complex Systems	Computing, Information and Communications Technology	Enabling Concepts and Technologies
Annual Performance Goal & APG #									
APG 3R1: Demonstrate progress in maturing, through flight tests and/or simulations, the critical technologies that will be necessary to meet the aviation safety objective. These tests and simulations are critical steps in the development of a suite of technologies that when completely developed and implemented by the customer, will provide a minimum of 50 percent reduction in fatal accident rate.		**X**	**X**						
APG 3R2: Complete combustor sector test for concepts capable of achieving the 70%NOX goal by 2007 and select the most promising approaches leading to full annular rig testing for large and regional jet engine applications. Complete an Interim Technology Assessment of the aggregate potential benefits from the engine and airframe technologies to reduce emissions. The results from this analysis will provide a benchmark for measuring overall progress, and guide future investment decisions.		**X**							
APG 3R3: Complete development of initial physics-based prediction models to guide the development potential noise reduction technology concepts. Complete an interim technology assessment of the potential benefits for these concepts to reduce noise emissions. The results from this analysis will provide a benchmark for measuring overall progress, and guide future investment decisions.		**X**							
APG 3R4: Complete development, initial functionality and evaluate human factors for at least one decision support tool to enable achievement of the planned progress towards the goal of doubling the capacity of the National Airspace System in 10 years. Complete the initial build of a toolbox of state-of-the-art airspace models to enable the planned progress towards the 2022 Objective.				**X**					

Aerospace Technology **FY 2003 Budget Link Table**	**Budget Category**	Vehicle Systems	Aviation safety	Airspace Systems	2nd Generation	3rd Generation	Engineering for Complex Systems	Computing, Information and Communications Technology	Enabling Concepts and Technologies
APG 3R5: Select candidate technologies for experimental flight evaluation based on their impact on mobility. Mobility metrics will be measured by accessibility, doorstep-to-destination transit time, system and user costs, and related trip reliability and safety metrics. These flight experiments will evaluate individually, at the sub-system level, the impact of selected technologies on lowering required landing minimums and increasing the volume of operations at non-towered landing facilities in non-radar airspace during instrument meteorological conditions		X		X					
APG 3R6: Down-select to a minimum of two launch architectures for detailed development based on their ability to meet the safety and affordability goals. This selection will determine what launch architectures and critical technology developments will be continued through FY 2006					X				
APG 3R7: Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations and associated ground technologies. This independent evaluation will validate ability of each propulsion system, a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine, to achieve the strategic objectives within cost and schedule.						X			
APG 3R8: Down-select to a minimum of two launch architectures for detailed development based on their ability to meet the safety and affordability goals. This selection will determine what RLV architectures and critical technology developments will be continued through FY 2006.					X				
APG 3R9: Complete the independent evaluation of three revolutionary hypersonic propulsion technology systems demonstrations and associated ground technologies. This independent evaluation will validate ability of each propulsion system, a rocket-based combined-cycle engine, a turbine-based combined cycle engine and a scramjet engine, to achieve the strategic objectives within cost and schedule.						X			

Aerospace Technology FY 2003 Budget Link Table	Budget Category	Vehicle Systems	Aviation safety	Airspace Systems	2nd Generation	3rd Generation	Engineering for Complex Systems	Computing, Information and Communications Technology	Enabling Concepts and Technologies
APG 3R10: Complete initial component tests to provide data for evaluating feasibility of key concepts by completing all of the following indicators.									X
APG 3R11: Complete development of an organizational risk model and establish initial high dependability computing testbeds and tools as defined in the following indicators.		X					X	X	X
APG 3R12: Advance the state-of-the-art in automated data analysis, mission command and communications, and science sensors and detectors that are potentially beneficial for future NASA missions.								X	X
APG 3R13: Advance the state-of-the-art in power / propulsion systems, spacecraft systems, and large or distributed space systems and our knowledge of space environmental effects that are required to support future NASA missions.		X							X
APG 3R14: Demonstrate progress toward achievement of systems and systems of systems that can think, reason, make decisions, adapt to change, and cooperate among themselves and with humans to provide safe and successful aerospace processes and mission functions with greatly reduced human participation by successfully demonstrating individual autonomy components.								X	X
APG 3R15: Implement an effective oversight process to insure that the research programs are addressing the correct areas, meeting user requirements, have the proper balance, are properly formulated and planned, and are making sufficient process toward the Enterprise goals		X	X	X	X	X	X	X	X
APG 3R16: To contribute toward maintaining a well-prepared workforce pipeline, all Enterprise program activities will establish and implement, or continue implementation of, an education outreach plan that results in an educational product. The product shall be consistent with the NASA Implementation Plan for Education and use program content to demonstrate or enhance the learning objectives.		X	X	X	X	X	X	X	X